Littoral Refractivity Prognostic Advancement

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LONG-TERM GOALS

The goal of this research is to improve Coupled Ocean/Atmosphere Prediction System (COAMPS®) to the point that it provides engineering quality refractivity fields in the littorals. These engineering quality refractivity fields will be able to support radio frequency system testing, acquisition, radar system performance forecasts and radar sea and land clutter forecasts.

OBJECTIVES

The objective of this research is to improve the Coupled Ocean/Atmosphere Prediction System (COAMPS®) atmospheric boundary layer (ABL) wind and refractivity field forecasts in the littorals with respect to error threshold requirements established by the chemical sensor testing, propagation, and surface radar sea and land clutter model communities. Assimilation of special field measurements will be investigated with a focus on improving the model forecast refractivity fields. This technology will provide situational awareness of the 3D radio-frequency (RF) propagation environment and a quantitative diagnostic and prognostic capability for assessing sub- and super-refractive conditions in the littorals. The research will lead to the exploitation of anomalous RF propagation fields in order to re-deploy spectrum, sensor, and communications assets to avoid propagation liabilities and to take advantage of propagation opportunities validating with US Naval surface sensor test data.

APPROACH

Leverage NSWCDD Chemical Agent Plume Tracking Capability (CAPTC) computational resources (two Linux clusters) to adapt COAMPS® – On Scene (COAMPS-OS®) coupled mesoscale forecast and data assimilation system in the testing of model advancements that directly impact the electromagnetic (EM) propagation environment over Wallops Is., VA. Benchmark error threshold diagrams will be analyzed from uncoupled and coupled model forecasts using field data to determine linkages between errors in state variables such as wind, SST, moisture gradient and inversion strength, to errors in ducting characteristics and to errors in EM propagation path loss. Error statistics will be compared

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14. ABSTRACT
The goal of this research is to improve Coupled Ocean/Atmosphere Prediction System (COAMPS?) to the point that it provides engineering quality refractivity fields in the littorals. These engineering quality refractivity fields will be able to support radio frequency system testing, acquisition, radar system performance forecasts and radar sea and land clutter forecasts.

15. SUBJECT TERMS

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with the benchmark showing the quantitative improvement with each stage of model development. Improvement associated with increased vertical resolution, new stable boundary layer physics, entrainment parameterization, and assimilation of special weather operation data will be investigated. Wallops Is. is selected to take advantage of the electromagnetic propagation assessments and dispersion tracking experiments, including environmental measurements, executed by NSWCDD. The combined focus of NRLMRY NWP researchers and NSWCDD propagation and dispersion researchers will stimulate and accelerate the state of the art for a high-resolution littoral environmental assessment capability.

WORK COMPLETED

Developed a surface layer model blending technique that extends modified refractivity profiles to the surface at each COAMPS® grid point. Modified the NSWCDD littoral clutter model (LCM) to accept COAMPS® derived refractivity fields. Analyzed the impact on ducting of increased COAMPS® vertical resolution. Assessed the temporal and spatial duct occurrence errors for the Wallops 2000 Microwave Propagation Measurement Experiment (MPME). Developed alternative statistical metrics for quantifying numerical weather prediction forecasts of modified refractivity based upon profile shape and slope. Evaluated the influence of spatial and diurnal variation in SST on coastal refractivity forecasts for the seven day MPME. Compared the MPME propagation measurements to a propagation model driven by COAMPS® refractivity data. Completed a two-way COAMPS® / NCOM coupling run with NCODA ocean data assimilation in near real time mode from February 1 to March 19, 2009 for the Bay of Plenty in New Zealand.

RESULTS

The surface layer blending technique is robust but is dependent on surface layer model solutions that sometimes fail in stable conditions. This demonstrates the need to have a backup surface layer model for these conditions. The LCM is a much improved engineering tool with COAMPS® refractivity fields and is now used to drive radar acquisition requirements. Higher vertical COAMPS® resolution is a necessary but not sufficient condition to represent atmospheric ducting. The evaluations of duct occurrence suggest that timing of synoptic transitions were frequently the source of errors in COAMPS® duct forecasts during MPME. The refractivity slope error metrics more appropriately characterize the accuracy of modified refractivity forecasts because they represent differences in the profile shape. Water vapor vertical distribution is the dominant factor impacting modified refractive forecasts and observations are necessary for the model to develop and retain correct vertical structure yielding more accurate ducting characteristics. The propagation comparisons indicated a strong situational awareness at the engineering level that supports acquisition engineering, but more accuracy is required to support operational reach back, quantitative at sea testing and real time adaptation for surface radars. The New Zealand Sea Breeze Trial (NZSBT) field data will provide an opportunity to assess COAMPS® skill in forecast refractivity from the one-way and two-way fully coupled systems.

The work described above led to the following publications.

Marshall, R. E., et al., “Modeling and Simulation of Notional Future Radar in Non-Standard Propagation Environments Facilitated by Mesoscale Numerical Weather Prediction Modeling,” accepted for publication in the Naval Engineers Journal

Marshall, R. E. and Haack, T., "Engineering Demands Placed on Littoral Radar due to Non-standard Propagation Revealed by Mesoscale Numerical Weather Prediction Technology," Proceedings of the International IEEE Radar Conference, Rome, Italy, March, 2008

Lefurjah, G., et al. "Clutter Forecast-A Synthesis of Numerical Weather Prediction and a Empirical Site Specific Clutter Models," Proceedings of the International IEEE Radar Conference, Rome, Italy, March, 2008

Haack, T., et al. "A Mesoscale Model Intercomparison of Boundary Layer Refractivity and Ducting Conditions during Wallops-2000, to be submitted to Journal of Applied Meteorology"

As a result of this work, Tracy Haack and Robert Marshall have been asked by the US Commission F of the International Union of Radio Science to organize and co-chair a special session on numerical weather prediction and wave propagation modeling at the January 2010 National Radio Science Meeting in Boulder, CO

IMPACT/APPLICATIONS

Radio frequency ducting and super-refraction are not resolved to the accuracy required for real time operational adjustments to radar engineering settings. However, the qualitative nature of COAMPS® refractivity fields is useful for qualitative radar testing and radar acquisition performance requirements. COAMPS® refractivity fields are now beginning to be used for forensic analyses of Fleet RF system failures or interference incidents.

TRANSITIONS

The COAMPS® refractivity fields are being employed by the Sensors Division at the Naval Surface Warfare Center, Dahlgren Division to establish performance specifications for future Navy radar and communication systems as part of the acquisition process. COAMPS® fields are also used to support over the water prototype radar and communication systems testing at Port Hueneme, the Potomac River Test Range, and Wallops Island, VA.

RELATED PROJECTS

The ABCANZ Numerical Weather Prediction Experiment involves mesoscale numerical weather prediction modelers and models from the UK Met Office, Environment Canada, New Zealand Defence Technology Agency, and the Austrailian Defence Science and Technology Organisation modeling the Wallops 2000 experiment and comparing results to the COAMPS® analysis.